

Title: Tracking the phenology of dryland vegetation with fused satellite imagery

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Abstract:

Understanding the mechanistic controls on tropical forests photosynthetic metabolism is a central problem of ecology and global change biology. We hypothesize two different temporal scales for the mechanisms regulating tropical photosynthesis (Gross Ecosystem Productivity, GEP): (1) at seasonal scales, leaf phenology (changing age and amount of leaves) is the primary control on GEP seasonality; (2) at the hourly scale with a constant phenological stage, climatic variables are the first order controls on GEP.

In order to test this hypothesis, we partitioned the sources of GEP variation measured on eddy flux towers in central Amazon forests into biological and climatic components. The biological component (photosynthetic capacity, or PC) was defined as the monthly mean value of GEP extracted under a fixed narrow range of climate conditions, representing phenological changes associated with the amount and age of leaves. The climatic component was extracted via a path analysis of the hourly flux data, conditioned on a given monthly PC, representing the effects of fluctuating climate operating on the given PC. The main climatic variables were PAR, air-temperature, VPD, and Cloudiness Index (CI), the fraction of reduction of incident solar radiance due to clouds and aerosols relative to that expected under clear sky conditions.

We found that the variability in monthly GEP arises from both seasonality of PC and that of climate, but despite the strong seasonality of climate, GEP was dominated by PC seasonality ($R^2=0.92$). We found that the variability in hourly GEP (relative to the potential represented by monthly PC) was controlled primarily by PAR and VPD (as modified by the influence of CI). The tradeoff between the positive GEP effects of increased PAR and the negative effects of higher VPD stress indicates that tropical forests are stable in the face of modest climatic variability. For example, a significant reduction in mean cloudiness (of 0.1 CI units, corresponding to a ~18% increase in PAR and ~19% increase in VPD) would cause only modest changes in GEP (~1.8% increase in the wet season and ~2.9% decline in the dry season). This work provides an improved framework for understanding the climate drivers of canopy scale photosynthesis by separately analyzing the influence of phenological and climatic components.